

Ionic Liquid Electrolytes

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Over the past several years, we have been developing electrolytes based on our ionic liquid technology (1) for electrochemical capacitors (2-8) and lithium batteries. Here we present some recent results.

Electric Double Layer Capacitor Electrolytes

Neat Ionic Liquids

The superior high temperature characteristics of the ionic liquids provide a unique solution to high temperature electrolyte problems associated with device internal pressure build-up, corrosion, and thermal stability (9). The neat ionic liquids have no measurable vapor pressure up to the decomposition temperature above 400 °C. The improved thermal stability of the imidazolium ionic liquids compared to the quaternary ammonium salts and the ability to formulate solvent free electrolytes with no vapor pressure offer significant advantage in the design and performance of EDLC devices.

The conductivity at elevated temperatures (*i.e.* 250 °C) is greater than 0.1 S/cm for EMIm, with a curved Arrhenius relationship. These data are best fit to the VTF equation over the nearly 300 °C temperature range.

Ionic Liquid Solutions

Ionic liquids can also be formulated with one or more organic solvents to provide electrolytes with exceptional performance (2,6). Competitive advantages offered by these solutions are high ion concentration (>2M), high room temperature (>60 mS/cm) and low temperature (10 mS/cm at -60 °C) conductivity, depending on the formulation.

EDLC Devices

We have assembled Ionic Liquid Electrochemical Capacitor (ILEC) coin cell, prismatic, and AA cell devices. The active (electrode and electrolyte) and inactive (separator) materials in these devices are stable at 250 °C.

The competitive advantage offered by Ionic Liquids as EDLC electrolytes are:

- High ion concentration
 - decreased electrolyte needs
 - reduced volume and weight requirements
- Superior conductivity
 - low ESR
 - increased power
- No vapor pressure
 - No phase changes
- Improved thermal stability
- Nonflammable
- Non-corrosive

Lithium and Lithium Ion Batteries

Ionic Liquids as thermally stable, nonflammable electrolytes for lithium batteries offer significant advantage in the development of state-of-the-art batteries.

- Nonflammable Batteries
- Plastic Prismatic Packaging

Ionic Liquids can be formulated in various phases, offering extreme versatility.

- Liquids
- Gels
- Polymers

Data will be presented on the use of various ionic liquid formulations incorporating Li salts for lithium intercalation into graphite and various graphite/cathode and lithium/cathode battery constructions. Cycling data and nonflammability will be discussed.

In addition to the application of these ionic liquids for electrochemical capacitors and lithium batteries, these materials provide unique commercial opportunities as lubricants, solvents, biphasic catalysts, plasticizers, and membrane materials in a wide variety of power source such as fuel cells.

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